Claims

[c1] 1. A fully automatic deionizer, comprising:
at least one treating unit, comprising an electrode module and a housing, wherein the electrode module comprises at least one pair of anode and cathode made by coating an active material on an electrically conductive substrate;
at least one DC power source to supply electricity to the electrode module for removing ionic species from liquids, i.e., for deionization;
at least one capacitor to store electricity extracted from the electrode module for desorbing the ionic species from the electrode module, i.e., for regenerating the electrode module;
at least one on-line sensor and at least one fluid valve for detecting and for diverting liquid flow in the treating unit; and
at least one micro-controller for controlling the deionization, the electricity extraction from the electrode module, and the liquid flow.

[c2] 2. The fully automatic deionizer of claim 1, wherein the active material is selected from a group consisting of activated carbon, C_{60}, carbon nanotube, MnO_2, Fe_3O_4 and combination thereof.

[c3] 3. The fully automatic deionizer of claim 1, wherein the electrically conductive substrate is selected from a group consisting of Ti, Pt and Pd.

[c4] 4. The fully automatic deionizer of claim 1, wherein the electrically conductive substrate is in the form of foil, plate, mesh, or web.

[c5] 5. The fully automatic deionizer of claim 1, wherein the electrode module is in the form of cylinder, cube, or rectangle.

[c6] 6. The fully automatic deionizer of claim 1, wherein the DC power source applies a DC voltage to the electrode module for a period from 30 seconds to 4 minutes for deionization.

[c7] 7. The fully automatic deionizer of claim 6, wherein more than 30% of a process energy of the deionization is recovered from the electrode module.

[c8] 8. The fully automatic deionizer of claim 1, which is designed so that electricity

is extracted from the electrode module in less than one minute.

[c9] 9. The fully automatic deionizer of claim 1, wherein a liquid is provided to transport the ionic species desorbed from the electrode module to a reservoir.

[c10] 10. The fully automatic deionizer of claim 9, wherein the ionic species are stored in the reservoir to be concentrated for recycle, for recovery, or for disposal.

[c11] 11. The fully automatic deionizer of claim 9, wherein the liquid is selected from a group consisting of fresh water, brine and seawater.

[c12] 12. The fully automatic deionizer of claim 1, wherein the capacitor is selected from a group consisting of supercapacitor, ultracapacitor and electric double layer capacitor.

[c13] 13. The fully automatic deionizer of claim 1, wherein the on-line sensor is used to on-line monitor conductivity, resistivity, pH, temperature, or optical absorbance of liquids.

[c14] 14. The fully automatic deionizer of claim 1, wherein the fluid valve is actuated and controlled by electrical current.

[c15] 15. The fully automatic deionizer of claim 1, comprising a plurality of treating units connected in series, a plurality of on-line sensors and a plurality of fluid valves, wherein at least one on-line sensor and at least one fluid valve are used for detecting and for diverting liquid flow in one treating unit.

[c16] 16. A fully automatic deionizer, comprising:
at least two sets of treating units, wherein each set comprises at least one treating unit that comprises an electrode module and a housing, wherein the electrode module comprises at least one pair of anode and cathode made by coating an active material on an electrically conductive substrate;
at least one DC power source to supply electricity to the electrode modules for removing ionic species from liquids, i.e., for deionization;
at least one capacitor to store electricity extracted from the electrode modules for desorbing the ionic species from the electrode modules, i.e., for

regenerating the electrode modules;

a plurality of on-line sensors and a plurality of fluid valves, wherein at least one on-line sensor and at least one fluid valve are used for detecting and for diverting liquid flow in one treating unit; and

at least one micro-controller for controlling the deionization, the electricity extraction from the electrode modules, and the liquid flow, wherein

a first set of treating units are switched to deionization and a second set to regeneration at one moment, while the first set of treating units are switched to regeneration and the second set to deionization at next moment.

[c17] 17. The fully automatic deionizer of claim 16, wherein the active material is selected from a group consisting of activated carbon, C_{60}, carbon nanotube, MnO_2, Fe_3O_4 and combination thereof.

[c18] 18. The fully automatic deionizer of claim 16, wherein the electrically conductive substrate is selected from a group consisting of Ti, Pt and Pd.

[c19] 19. The fully automatic deionizer of claim 16, wherein the electrically conductive substrate is in the form of foil, plate, mesh, or web.

[c20] 20. The fully automatic deionizer of claim 16, wherein the electrode module is in the form of cylinder, cube, or rectangle.

[c21] 21. The fully automatic deionizer of claim 16, wherein the DC power source applies a DC voltage to the electrode module for a period from 30 seconds to 4 minutes for the deionization.

[c22] 22. The fully automatic deionizer of claim 21, wherein more than 30% of a process energy of the deionization is recovered from the electrode modules.

[c23] 23. The fully automatic deionizer of claim 16, which is designed so that electricity is extracted from the electrode modules in less than one minute.

[c24] 24. The fully automatic deionizer of claim 16, wherein a liquid is provided to transport the ionic species desorbed from the electrode modules to a reservoir.

[c25] 25. The fully automatic deionizer of claim 24, wherein the ionic species are

stored in the reservoir to be concentrated for recycle, for recovery, or for disposal.

[c26] 26. The fully automatic deionizer of claim 24, wherein the liquid is selected from a group consisting of fresh water, brine and seawater.

[c27] 27. The fully automatic deionizer of claim 16, wherein the capacitor is selected from a group consisting of supercapacitor, ultracapacitor and electric double layer capacitor.

[c28] 28. The fully automatic deionizer of claim 16, wherein the on-line sensors are used to on-line monitor conductivity, resistivity, pH, temperature, or optical absorbance of liquids.

[c29] 29. The fully automatic deionizer of claim 16, wherein the fluid valves are actuated and controlled by electrical current.

[c30] 30. The fully automatic deionizer of claim 16, wherein each set of treating units comprises a plurality of treating units that are connected in series, a plurality of on-line sensors and a plurality of fluid valves.